WHAT IS CLAIMED IS:

1. A quantum dot, comprising:

a nanocrystalline core exhibiting quantum confinement and having a band gap;

a luminescence promoter linked to the surface of the nanocrystalline core;

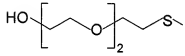
a non-zinc linking group;

an ethylene glycol unit linked to the surface of the nanocrystalline core through the linking group; and

the luminescence promoter selected from the group consisting of an ethylene glycol unit, an alkylthio acid, mercaptoacetic acid, and any combination.

2. The quantum dot of claim 1, wherein the linking group does not comprise a group VA or VIA element which is present in the nanocrystalline core.

3. The quantum dot of claim 1, comprising a group of formula XI, comprising a sulfur atom, wherein the sulfur atom is linked to the surface of the nanocrystalline core.



XI

4. The quantum dot of claim 1, wherein the nanocrystalline core comprises cadmium telluride.

5. A quantum dot, comprising:

a nanocrystalline core exhibiting quantum confinement and having a band gap;

a luminescence promoter linked to the surface of the nanocrystalline core; and

a biofunctional group linked to the surface of the nanocrystalline core,

wherein the luminescence promoter does not comprise a mercaptoalkanoic acid.

6. A quantum dot, comprising:

a nanocrystalline core exhibiting quantum confinement and having a band gap;

a luminescence promoter linked to the surface of the nanocrystalline core;

a non-zinc linking group; and

a biofunctional group linked to the surface of the nanocrystalline core through the linking group,

wherein the luminescence promoter is selected from the group consisting of an ethylene glycol unit, an alkylthio acid, mercaptoacetic acid, and any combination.

7. The quantum dot of claim 6, wherein the quantum dot is stable in aqueous solution under storage in the dark at 4 °C for at least 4 months with respect to luminescence, precipitation, flocculation, and leaching of the biofunctional group.

8. The quantum dot of claim 6,

wherein the luminescence promoter is a mercaptoalkanoic acid,

wherein the mercaptoalkanoic acid is not linked to the surface of the nanocrystalline core through a zinc atom, and

wherein the biofunctional group is not linked to the surface of the nanocrystalline core through a zinc atom.

9. The quantum dot of claim 6, wherein

the luminescence promoter is mercaptoalkanoic acid,

the mercaptoalkanoic acid is not linked to the surface of the nanocrystalline core through a group VA or VIA element which is present in the nanocrystalline core, and

the biofunctional group is not linked to the surface of the nanocrystalline

core through a group VA or VIA element which is present in the nanocrystalline core.

10. The quantum dot of claim 6, wherein the luminescence promoter comprises a non-zinc linking group and an ethylene glycol unit linked to the surface of the nanocrystalline core through the linking group.

11. The quantum dot of claim 6, wherein the linking group does not comprise a group VA or VIA element which is present in the nanocrystalline core.

12. The quantum dot of claim 6, further comprising a substantially zinc-free shell layer overcoating the nanocrystalline core.

13. The quantum dot of claim 12,

the shell layer comprising cadmium sulfide and/or mercury sulfide; and

the nanocrystalline core comprising a material selected from the group consisting of cadmium telluride, cadmium selenide, mercury telluride, mercury selenide, and/or any combination of these.

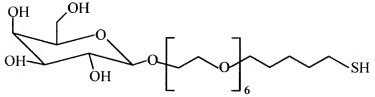
14. The quantum dot of claim 12,

comprising a group of formula XXX, comprising a sulfur atom,

wherein the sulfur atom is linked to the surface of the nanocrystalline core,

wherein the shell layer comprises mercury sulfide, and

wherein the nanocrystalline core comprises mercury telluride and/or mercury selenide.



XXX

15. The quantum dot of claim 6, wherein the biofunctional group comprises at least one biofunctional unit which is not a peptide.

16. The quantum dot of claim 6, the biofunctional group comprising a biofunctional unit selected from the group consisting of a monosaccharide unit, a mononucleoside unit, a mononucleotide unit, a monopeptide unit, a glycopeptide unit, and any combination of these.

17. The quantum dot of claim 6, the biofunctional group comprising a biofunctional unit comprising a lipid unit and/or a glycolipid unit.

18. The quantum dot of claim 16, the biofunctional group not comprising mannose or dextran.

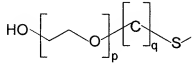
19. The quantum dot of claim 6, the biofunctional group comprising at least one tumor-associated carbohydrate.

20. The quantum dot of claim 6, wherein the biofunctional group comprises a Thomsen-Friedenreich disaccharide.

21. The quantum dot of claim 20, that selectively complexes to endothelial cells.

22. The quantum dot of claim 20, that is substantially retained by agarose-bound galactose specific peanut agglutinin and that is not substantially retained by agarose-bound mannose/glucose-specific *Pisum savitum* agglutinin.

23. The quantum dot of claim 6, comprising an ethylene glycol thiol of formula XIII comprising a sulfur atom,



XIII

wherein the sulfur atom is linked to the surface of the nanocrystalline core, p is a positive integer, and q is an integer of at least two.

24. The quantum dot of claim 10, comprising a branched linked chain comprising the ethylene glycol unit.

25. The quantum dot of claim 6, comprising a carboxylic acid unit linked to the surface of the nanocrystalline core.

26. The quantum dot of claim 6, comprising:

an ethylene-glycol-containing linked chain; and

a biofunctional-group-containing linked chain,

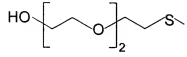
wherein the ethylene-glycol-containing linked chain does not comprise a biofunctional group and

wherein the biofunctional-group-containing linked chain does not comprise an ethylene glycol unit.

27. The quantum dot of claim 26, wherein the ethylene-glycol-containing linked chain comprises from 3 to 6 ethylene glycol units.

28. The quantum dot of claim 6, comprising:

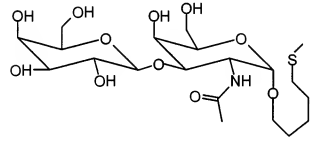
an ethylene-glycol-containing linked chain of formula XI, the sulfur atom of the ethylene-glycol-containing linked chain of formula XI linked to the surface of the nanocrystalline core; and



XI

a biofunctional-group-containing linked chain of formula XXVIIa, comprising a Thomsen-Friedenreich disaccharide as the biofunctional group and five carbon atoms and a sulfur atom,

wherein the sulfur atom of the biofunctional-group-containing linked chain of formula XXVIIa is linked to the surface of the nanocrystalline core.



XXVIIa

29. The quantum dot of claim 6, comprising:

a biofunctional-group-containing linked chain, wherein

an ethylene glycol unit is part of the biofunctional-group-containing linked chain and

the biofunctional group is part of the biofunctional-group-containing linked chain.

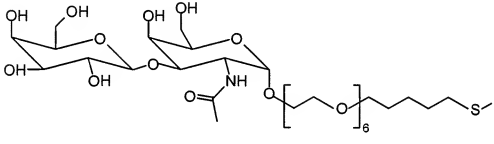
30. The quantum dot of claim 6, further comprising

a biofunctional-group-containing linked chain of formula XXVIIb,

comprising a Thomsen-Friedenreich disaccharide as the biofunctional group and

comprising six ethylene glycol units, five carbon atoms, and a sulfur atom,

wherein the sulfur atom of the biofunctional-group-containing linked chain of formula XXVIIb is linked to the surface of the nanocrystalline core.



XXVIIb

31. A formulation comprising:

a liquid; and

the quantum dot of claim 6,

wherein the quantum dot is dissolved or suspended in the liquid.

32. The quantum dot of claim 6, that is stable in aqueous solution under storage at room temperature in ambient lighting for at least 4 months with respect to luminescence, precipitation, and flocculation.

33. A method of imaging, comprising:

providing the quantum dot of claim 6;

contacting the quantum dot with a biological material;

exposing the biological material to light having a wavelength effective to cause the quantum dot to luminesce; and

imaging the luminescing quantum dots.

34. The method of claim 33, wherein the biofunctional group exhibits high affinity to tissue in a diseased or abnormal state, and the quantum dot luminescence images the tissue.

35. The method of claim 34, the diseased or abnormal state being cancerous.

36. A method of therapy, comprising:

providing the quantum dot of claim 6; and

contacting the quantum dot with a biological material and thereby treating a disease.

37. The method of claim 6, the biofunctional group comprising an immune-response stimulating group.

38. The method of claim 6, the biofunctional group comprising a tumor-associated antigen.

39. The method of claim 6, wherein the quantum dot further comprises a therapeutic agent linked to the surface of the nanocrystalline core.

40. The method of claim 6, wherein a shell layer and/or the nanocrystalline core comprises a therapeutic agent.

41. A quantum dot coated device, comprising the quantum dot of claim 6 linked to the surface of the device to form a coating on the device.

42. A cell-quantum dot complex, comprising:

a cell; and

the quantum dot of claim 6,

wherein the biofunctional group is complexed with the cell.

43. A method for producing a quantum dot, comprising:

providing a luminescence promoter;

refluxing the luminescence promoter with a group IIB element salt, a hydrogen-alkali-group VIA element compound, and a suitable solvent to produce a quantum dot in a solution,

wherein the luminescence promoter is selected from the group consisting of an ethylene glycol unit, an ethylene glycol thiol, an alkylthio acid, mercaptoacetic acid, and any combination of these.

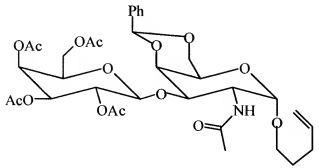
44. The method of claim 43, comprising:

providing a biofunctional group-thiol, comprising a biofunctional unit; and

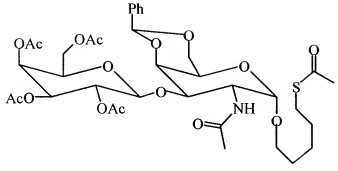
refluxing the biofunctional group-thiol and the luminescence promoter with a group IIB element salt, a hydrogen-alkali-group VIA element compound, and a suitable solvent to produce a quantum dot in a solution.

45. The method of claim 44, comprising:

reacting a glycoside of formula IV with an alkylthio acid in the presence of 2,2'-azobisisobutyronitrile in 1,4-dioxane at about 75 °C to produce a thioester of formula V;



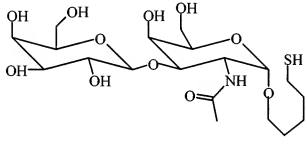
IV



V

debenzylidinating the thioester of formula V;

hydrolyzing the debenzylidinated thioester of formula V to produce a Thomsen-Friedenreich-thiol of formula VI; and



VI

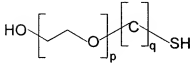
refluxing the Thomsen-Friedenreich-thiol of formula VI with cadmium perchlorate, a luminescence promoter, hydrogen sodium telluride, and a suitable solvent, to produce a Thomsen-Friedenreich-functionalized quantum dot in a solution,

wherein the suitable solvent comprises water and/or N,N-dimethylformamide.

46. The method of claim 43,

wherein the luminescence promoter comprises an ethylene glycol thiol,

wherein the ethylene glycol thiol is of formula XIII, and



XIII

wherein p is a positive integer and q is an integer of at least two.

47. The method of claim 43,

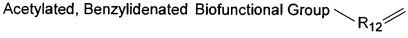
wherein the group IIB element salt is cadmium perchlorate and

wherein the hydrogen-alkali-group VIA element compound is hydrogen sodium telluride.

48. The method of claim 43, wherein the suitable solvent comprises water and/or N,N-dimethylformamide.

49. The method of claim 44, further comprising:

reacting a glycoside of formula XVIII with an alkylthio acid in the presence of a catalyst to produce an acetylated, benzylidenated biofunctional group thiol of formula XIX;

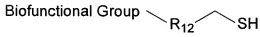


XVIII

XIX

debenzylidenating the thioester of formula XIX; and

hydrolyzing the thioester of formula XIX to produce the biofunctional group-thiol of formula XVb,

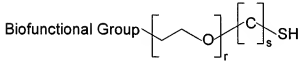


XVb

wherein R_{12} comprises a carbon atom and R_{13} comprises a carbon atom.

50. The method of claim 44,

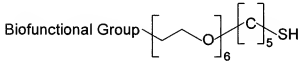
wherein the biofunctional group-thiol comprises a thiol of formula XVIb and



XVIb

wherein r is a positive integer and s is an integer of at least two.

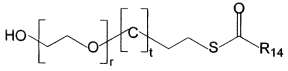
51. The method of claim 50, wherein the biofunctional group-thiol comprises a thiol of formula XVIIb.



XVIIb

52. The method of claim 50, further comprising:

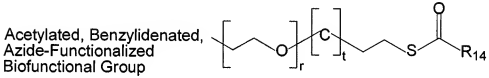
reacting a compound comprising ethylene glycol of formula XXb



XXb

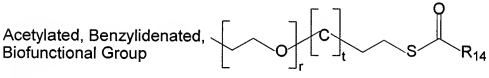
with a glycoside having azide and a group of formula XXbb as pendant groups and quenching the reaction with triethylamine to produce a compound of formula XXIIIb;

XXbb



XXIIIb

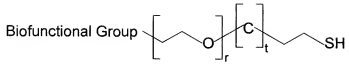
treating the compound of formula XXIIIb with acetic anhydride and a reducing agent to produce a compound of formula XXIIIc in which the azide group of formula XXIIIb is replaced with an acetamido group;



XXIIIc

debenzylidenating the compound of formula XXIIIc; and

hydrolyzing the compound of formula XXIIIc to produce the biofunctional-group thiol of formula XXIVb,



XXIVb

wherein r is a positive integer, t is zero or a positive integer, and R_{14} comprises a carbon atom.

53. The method of claim 52, wherein the group IIB element salt is cadmium perchlorate,

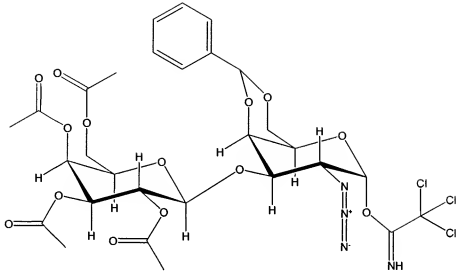
wherein the hydrogen-alkali-group VIA element compound is hydrogen sodium telluride,

wherein r is six and t is three,

wherein R_{14} is methyl,

wherein the glycoside having an azide and a group of formula XXbb as pendant groups has formula XXII,

XXbb



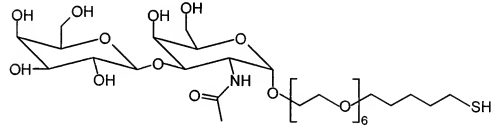
XXII

wherein the reducing agent is zinc,

wherein the debenzylidenating comprises treatment with acetyl chloride and quenching with pyridine;

wherein the hydrolyzing comprises treatment with sodium methoxide and quenching with ion-exchange resin, and

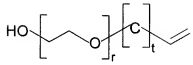
wherein the biofunctional-group thiol is of formula XXIVc.



XXIVc

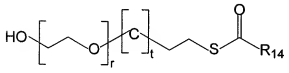
54. The method of claim 52, further comprising:

reacting a polyethylene glycol with sodium hydroxide and a brominated alkene to produce a compound of formula XXa; and



XXa

reacting the compound of formula XXa with an alkylthio acid in the presence of a catalyst to produce a compound of formula XXb,



XXb

wherein r is a positive integer, t is zero or a positive integer, and R_{14} comprises a carbon atom.

55. The method of claim 44, comprising refluxing the biofunctional group-thiol of formula III with a group IIB element salt, a hydrogen-alkali-group VIA element compound, and a suitable solvent to produce a quantum dot in a solution,

III

wherein R_1 comprises a carbon atom and/or an ethylene glycol unit,
wherein the group IIB element comprises cadmium and/or mercury, and
wherein the group VIA element comprises tellurium and/or selenium.